Japanese Unexamined Patent Application Publication No. 8-298315

SPECIFICATION <EXCERPT>

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[0012]

[Example] Hereafter, the embodiment of the present invention is described in more detail. FIG. 1 is a view showing one embodiment of the solid-state imaging device according to the present invention. The numeral 11 in FIG. 1 is a solid-state imaging device. The solid-state imaging device 11 differs from the solid-state imaging device 1 shown in FIG. 5 in the structure of the micro lens formed on the flat transparent layer 8. That is, in the solid-state imaging device 11 shown in FIG. 1, the flat transparent layer 8 is formed on the insulator layer 5 and the protective film 7 which cover the light-sensing surface 3a of the light sensing portion 3, and the lens part 12 is formed on this flat transparent layer 8. Here, the light-sensing surface 3a is formed to have a shape of a plane view abbreviation square, as shown in FIG. 2. The flat transparent layer 8 is made of transparent resin, such as polystyrene resin or an acrylic resin.

[0013] The lens part 12 is made of concave gratings, and has a shape of a zone plate which converges light on the light-sensing surface 3a. In the present embodiment, the lens part 12 is made of a full flannel zone plate. The lens part 12 of the full flannel zone plate is made of transparent resin, such as photoresist, and has a plane view shape as shown in FIG. 2. That is, the lens part 12 has a plurality of circular zona orbicularises 12a in a concentric circle shape, and according to the difference of the refractive index

between the zona-orbicularis 12a ... and the air layer 13 formed among these zona-orbicularises 12a, light from the zona-orbicularis 12a is converged on one point, thereby changing a light transmission rate and a phase of every other zona-orbicularis 12a having a narrower width when the zona-orbicularis 12 is nearer the periphery.

[0014] Here, radius r_m of the peripheral circle of the m-th zona orbicularis 12a is shown by

$r_m=(m\lambda f)^{1/2}$

towards the outside from the central zona orbicularis 12a. (Here, f expresses a focal distance and λ expresses a wavelength.)

Therefore, if a distance from the focal distance, namely, a sensor surface of the solid-state imaging device, to the flat transparent layer 8 in which the lens layer 12 is formed is assumed to be 6 μm, and a light wavelength is assumed to be 500 nm, a radius r_m of the outside of each zona orbicularis 12a is as follows.

When m= 1, r_m=1.73 μm,

When m=2, r_m=2.45 μm,

When m=3, r_m=3.00 μm,

When m=4, r_m=3.46 μm,

When m=5, r_m=3.87 μm, and

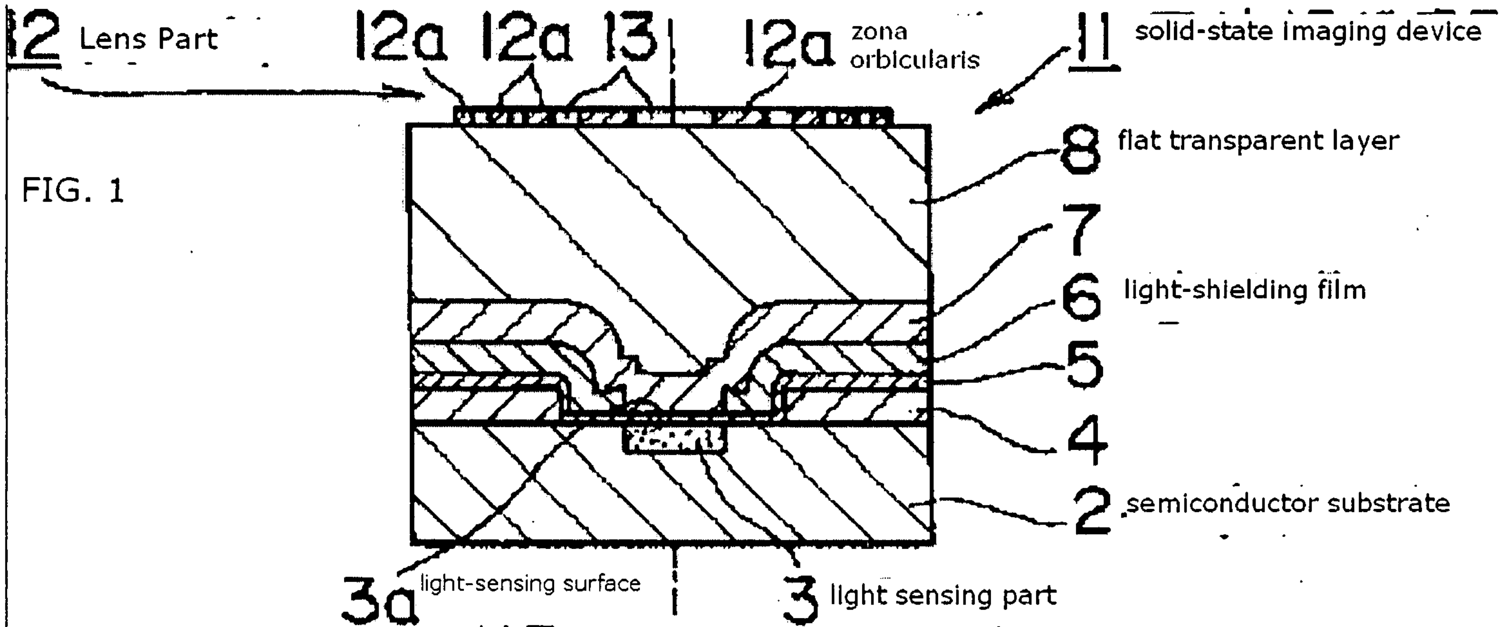
When m=6, r_m=4.24 μm.

A height (thickness) of each of these zona orbicularises 12a is ranged from about 0.1 μm to 0.5. The focal point of the lens part 12 made of full flannel zone plate having the above structure is positioned on the light-sensing surface 3a, and focal lens patterns P of the lens part 12 has a dot shape.

[0015] Next, based on the manufacturing method of the solid-state imaging device 11 having the above structure, the first embodiment of the manufacturing method of Claim 4 of the present invention is described. As shown in FIG. 3(a), on the semiconductor substrate 2, respective components which are the light sensing part 3, a

transfer register (not shown), a channel stop (not shown), and the like are in the same manner as conventional manner, using photoresist technology, ion implantation technology, and the like. Then, on the resulting, the transfer electrode 4, the insulator layer 5, the light-shielding film 6, and the protective film 7 are formed in the same manner as the conventional manner, using technologies such as photoresist, ion implantation, thermal oxidation, and deposition, and the like. Next, in order to cover the protective film 7, a transparent material such as transparent resin an including polystyrene resin and an acrylic resin is applied on the resulting, thereby forming the flat transparent layer (first transparent material layer) 8 as shown in FIG. 3(b). Here, in the formation of the flat transparent layer 8, a top surface of the flat transparent layer 8 is flatten by the method of known art.

FIG. 1



Schematic View of Embodiment

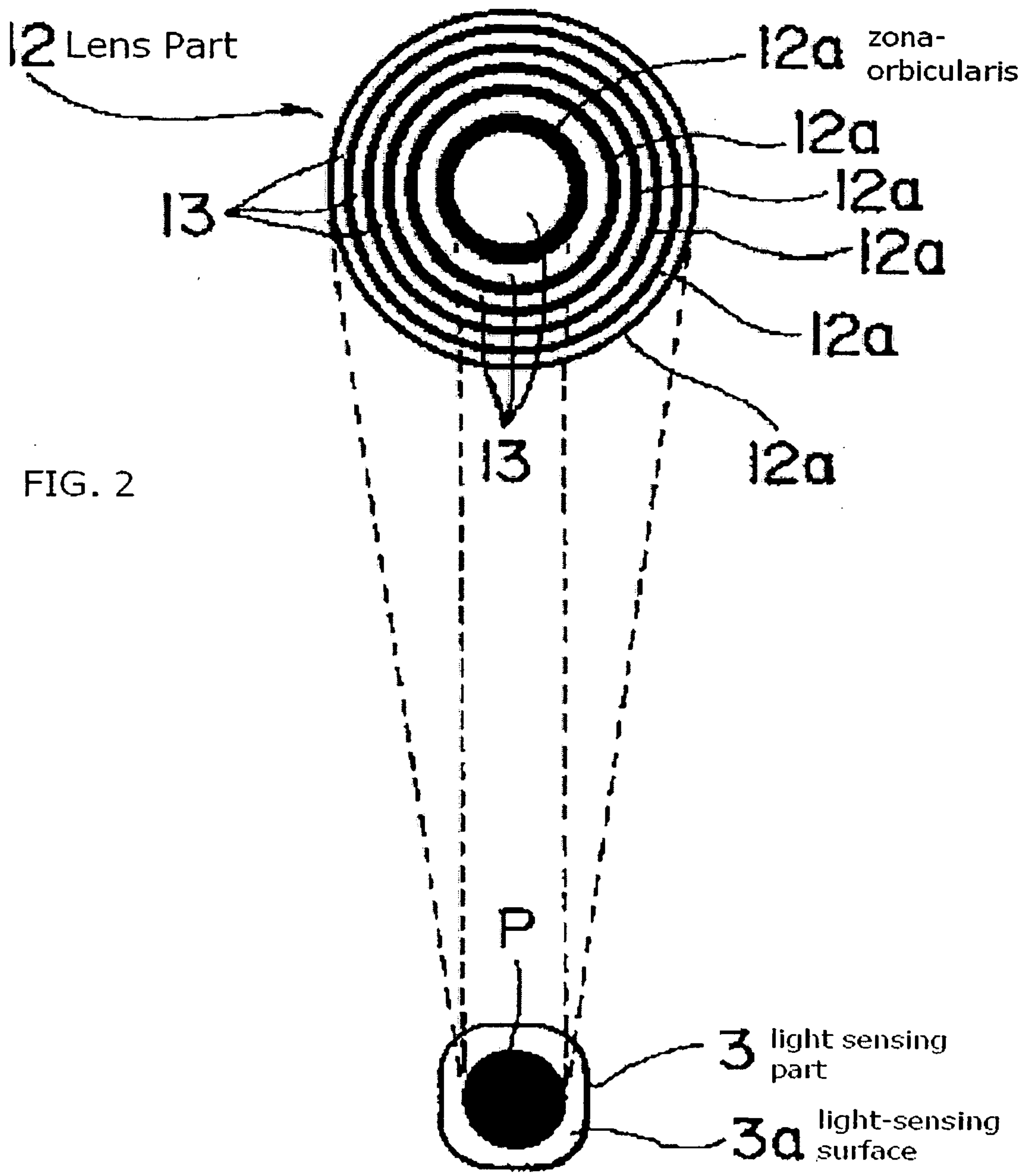
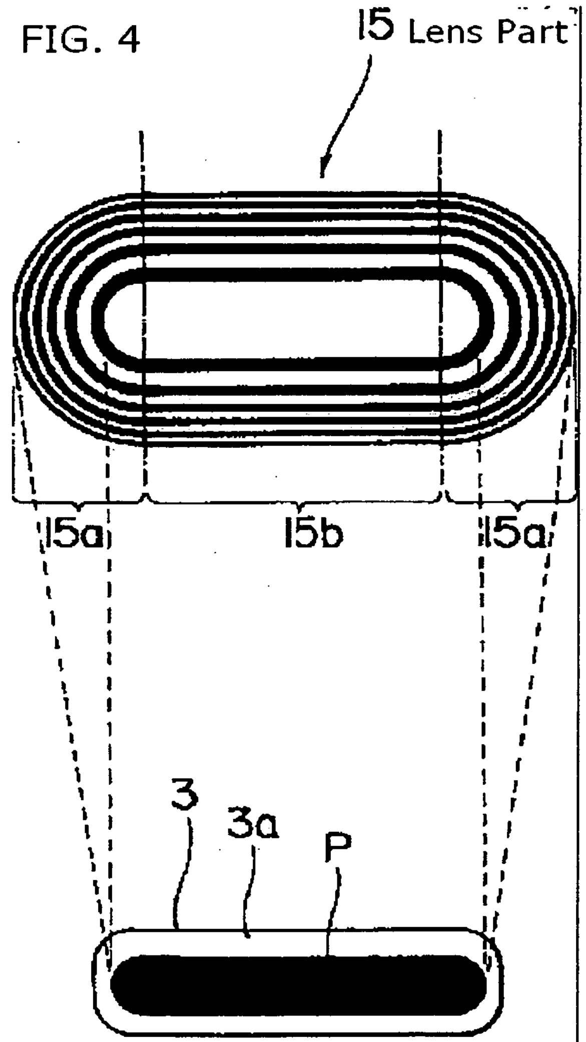


FIG. 2

Plan View of Lens Part and Light-Sensing Surface

FIG. 4



Plan View of Lens Part and
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